Lecture 15
March 8, 2005

Know:

1. The definitions of electric current
2. The definition of resistance
3. Ohm's Law relating current, potential difference, and resistance to each other
4. The definition of electric resistance and electrical power
5. The difference between direct current (d.c.) and alternating current (a.c)

Understand:

1. How current flow in a complete circuit
2. How to use Ohm's Law to calculate current, potential difference or resistance in a circuit
3. How to reduce series or parallel combinations of resistance to a single resistance
4. How to calculate the power supplied by or dissipated by a circuit element

The current (measured in Amperes) in a circuit is
A. the amount of charge (measured in Coulombs) that passes a point (in the circuit) in 1 second.
B. the amount of the total energy carried by 1 Coulomb of charge.
C. the total number of electrons in the circuit.
D. never lethal if the current is due to positive charges.

The resistance of a circuit element is a measure of
A. the total energy of the charges in the circuit element.
B. the amount of work that an electron can perform.
C. the ratio of the voltage difference between element ends to the current in the element.
D. the size of the circuit.

A certain kind of light bulb carries 1.5 amperes of current when connected to a 120 Volt AC circuit. What is its power rating?
A. 240 W B. 180 W
C. 80 W D. 100 W

Electric Currents

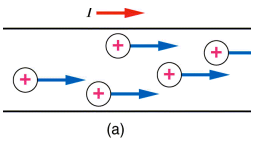
- The flow of charge through a conductor (eg metal wire) is called an electric current.
- On the microscopic level, a current is due to the flow of **electrons**. Conductors are conductors because the electrons are mobile.
- The amount of current is the rate at which charge is transferred through the conductor

$$I = q / t$$

I = current (Ampere)
Q = charge (Coulomb)
t=time (seconds)

Current in a wire

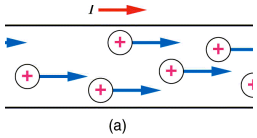
- A wire will have a current of 1 ampere (A) when 1 coulomb (C) of charge is transferred in 1 second.



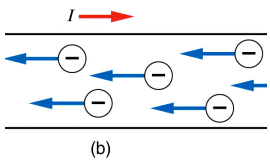
- Note: 1 coulomb is a large charge but the current of 1 ampere = 1 coulomb/second is an ordinary current (for example current flowing in a 150W light bulb is a little more than 1 A)

Current in a wire

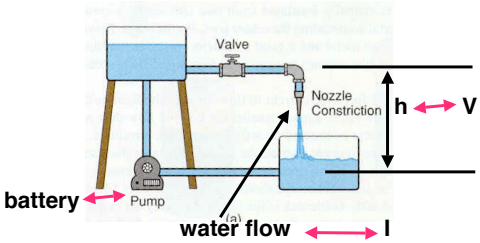
- Current is always in the **same direction** the **positive** charge would be moving.



- Current is always in the **opposite direction** the **negative** charge would be moving



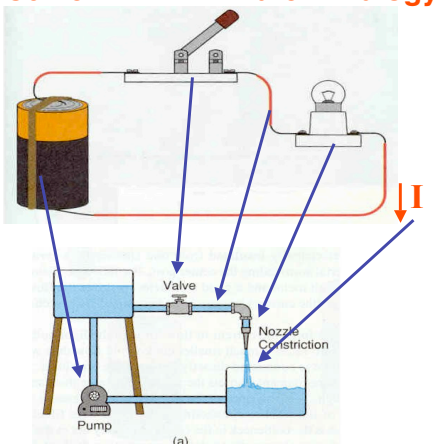
Electric Current → Water Analogy

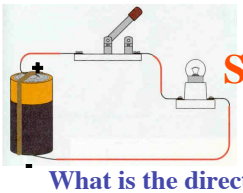


Current: number of electrons passing through per second

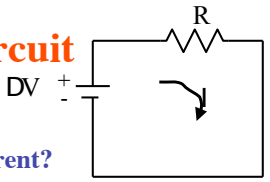
Water analogy: number of water molecules passing through per second

Electric Current ⟷ Water Analogy (II)





Simple Circuit



What is the direction of the current?

- Same as the **positive charges** from positive to negative.
- Why? Early scientists and inventors like Benjamin Franklin didn't understand the atomic structure and made the incorrect assumption that positive charges were flowing through the conductors

- In reality the current is due to the flow negative charges.

Ohm's Law

Georg Simon Ohm (1787-1854) discovered the relationship between voltage and current

- Resistance it the measure of a material's ability to resist the flow of of electrons.
- It is measured in Ohms (Ω).
- Ohm's Law: current in a circuit is equal to the potential divided by the resistance

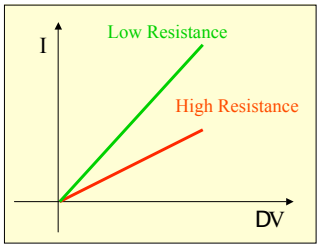
$$I = \frac{\Delta V}{R}$$

DV = voltage or potential
I = current
R = resistance

See applet

Graphing Ohm's Law

$$I = \frac{\Delta V}{R}$$



- Relationship between Current and Voltage difference is linear
- Slope is equal to the inverse of the resistance

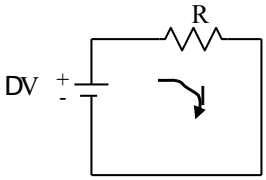
Study the Simple Circuit

Ohm's Law:

$$I = \frac{\Delta V}{R}$$

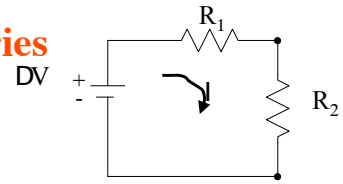
$$\Delta V = IR$$

$$R = \frac{\Delta V}{I}$$



NOTE: The current flows from positive to negative (opposite to the electron flow)

Resistors in Series



- When all elements in a circuit are on the single loop we say that resistors are in series
- This means the same current is passing through all resistors
- For resistors in series we can calculate the total resistance (R_T)of the circuit as the sum of all resistances in series, in the example above:

$$R_T = R_{series} = R_1 + R_2$$

Resistors in Series (II)

- To find the total resistance of N resistors in series use:

  $R_T = R_1 + R_2 + R_3 \ldots + R_N$

- Once the total resistance is known, the current is:

  $I = \Delta V / R_T$

- The potential or voltage across each resistor is:

  $V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$ etc.

Class Exercise # 7 - Mar. 8, 2005

(Write your name and section number)

Here are five statements about electric force. Say whether each is true or false and explain why. (A good explanation, or an example, is necessary for full credit)

1. The electric force between two electric charges is always an attractive force.
2. The electric force is proportional to the inverse of the square of the distance between two charge particles.
3. It is possible for two objects to have both an attractive gravitational force and an attractive electrical force between them.
4. The electron and the proton have exactly the same charge.
5. The electric force between two electrons separated by a distance d is smaller in magnitude than that between two protons separated by the same distance d because the protons are more massive.